MATERIAL CONTROL AND WEAPON SYSTEM
COSTING UNDER THE NAVY MAINTENANCE
AND MATERIAL MANAGEMENT
SYSTEM (AVIATION)

By

Robert Eugene Flolid

MATERIAL CONTROL AND WEAPON SYSTEM COSTING UNDER THE NAVY MAINTENANCE AND MATERIAL MANAGEMENT SYSTEM (AVIATION)

By

Robert Eugene Flolid

MATERIAL CONTROL AND WEAPON SYSTEM COSTING UNDER
THE NAVY MAINTENANCE AND MATERIAL
MANAGEMENT SYSTEM (AVIATION)

By

Robert Eugene Flolid

Bachelor of Arts

St. Cloud State College, 1951

A Thesis Submitted to the School of Government and
Business Administration of The George Washington
University in Partial Fulfillment of the
Requirements for the Degree of
Master of Business Administration

June, 1967

Thesis directed by

Dr. Paik

PREFACE

In April of 1965, I reported for duty on the staff of Commander Naval Air Force, U.S. Atlantic Fleet. My main duty, while working for the Assistant Chief of Staff for Supply in the Planning Section, was to be focused around the implementation of a new Standard Navy Maintenance and Material Management System. For convenience I will hereafter refer to the program as 3M, its commonly accepted acronym.

Although 3M (aviation) was initially tested in the Navy in April 1964, it was still a new program and would not be totally implemented in the Atlantic Fleet and supporting Air Stations until July, 1966. During the implementation of 3M on many Atlantic Fleet Aircraft Carriers and Naval Air Stations, the question most frequently asked was: "What will 3M do for us?" It was a difficult question to answer, because the system was so new that recognizable results were not available. The purpose of this paper is to attempt to give some answers to this very question by reviewing the material control aspects of 3M that have now been utilized for a test period of a year. In addition, the weapon system costing concepts of 3M will be analyzed for future value when implemented.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

Early History

The technological changes occurring in the twentieth century could not be better exemplified than by the changes that have taken place in aviation, and in particular Naval Aviation. Present-day operational Naval aircraft can now fly at three times the speed of sound. Some aircraft have the electronic capability of detecting an enemy target without seeing it. With computer speed and accuracy a weapon can be released that will destroy the target, and the plane can return to its base and land under control of guidance systems never dreamed of 40 years ago.

A visit to the Smithsonian Museum in Washington, D.C., and a look at the original flying machines will soon convince anyone that aviation has come a long way. On display is Charles Lindbergh's "Spirit of St. Louis." It is hard to conceive of this aircraft flying nonstop across the Atlantic. It is also difficult to realize the unsophisticated nature of the plane's maintenance capability. Displayed near the plane were the few simple tools that Lindbergh required to maintain his aircraft, one six-inch crescent wrench, one five-inch pliers and one six-inch screwdriver.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

In the early days of Naval Aviation the airplanes were simple flying machines, and a few basic tools were used to maintain them. The pilot both flew the plane and served as the mechanic. From this pilot-mechanic concept Naval Aviation progressed by World War II to the Squadron maintenance concept. Each Squadron had its own maintenance facility and supporting equipment. Then to conserve personnel, facility space and material, the Fleet Aircraft Service Squadron (FASRON) was formed. Its main task was to provide aircraft maintenance support to Fleet Squadrons. There still was duplication of Aircraft Maintenance facilities because the Air Station, on which the FASRON was located, continued to accomplish its own maintenance on the Station aircraft.

Finally in October 1959, as a result of OPNAV Instruction 5400.5,[1] a Naval Aircraft Maintenance Program was established. The FASRON concept was disestablished and the Air Station became the Maintenance Support Activity for Fleet Squadrons based aboard the Station.

> The Naval Aircraft Maintenance Program, as formally implemented in October, 1959, sub-divided the Department of Defense established three levels of maintenance into six maintenance echelons or levels. (A, B, C, D, E, & F) At that point in time, this course of action was considered appropriate in recognition of (1) limited maintenance space aboard Aircraft Carriers and (2) the desire to maintain a limited shop repair capability in Fleet Squadrons during deployment, as a means of providing a limited degree of Squadron self-sufficiency within limited personnel and fund resources. However, after three and one-half years, it became obvious that further centralization was

---

[1]U.S. Department of the Navy, Office of the Chief of Naval Operations, OPNAV Inst. 5400.5, "Naval Aircraft Maintenance Program," Oct., 1959.

> necessary. The six levels of maintenance concept did not provide a method for adequately defining the division between C and D levels. This was the off aircraft maintenance responsibility conflict between Fleet and Station personnel. [There was an overlapping maintenance responsibility that did not clearly define which activity was to take repair action under varying conditions.] This resulted in problems concerning allocation of tools and equipment, distribution of personnel and assignment of shops and spaces, development of technical publications to clearly align responsibilities, and the funding of the Component Repair Program. After a review it was determined that the Three Levels of Maintenance Concept should be adopted.[1]

Three Levels of Maintenance

The Navy was now ready to operate under the Department of Defense Maintenance Concept. The former six levels of maintenance were realigned as follows. Classes A and B were combined into Depot Maintenance:

> That type of work that must be done in an industrial type facility. Such facilities may be either military or commercial. This level of maintenance includes overhaul and major repair and modification of aircraft, components and equipments. It also includes the manufacture of designated aeronautical parts as system spares and the manufacture of kits for the accomplishment of aircraft and equipment modifications. Support is service wide.[2]

Classes C and D were combined into Intermediate Maintenance:

> That type of work that is performed in centrally located facilities (afloat or ashore) for the support of operating units within a designated area or at a particular base or station. This level of maintenance includes shop type repair and test work on aircraft components and equipment from the supported units. Technical assistance, when required, is furnished to the supported operating units.[3]

---

[1]U.S. Department of Navy, Bureau of Naval Weapons, BuWEPS Inst. 4700.2A, "The Naval Aircraft Maintenance Program," Oct., 1964, pp. 2-3.

[2]*Ibid.*, pp.2-4.

[3]*Ibid.*

Finally, Classes E and F were combined into

Organizational Maintenance:

> That type of work performed by the operating unit on a day-to-day basis in support of its own operations. Maintenance performed at this level includes line operations (servicing, daily/pre-flight inspections, minor adjustments, etc., in preparation for flight); periodic inspections of aircraft and equipment; and the associated tests, repairs and adjustments which do not require shop facilities. All such work is done in facilities assigned to the operating units on either a joint or individual basis.[1]

This new three level maintenance concept was implemented as a result of the BUWEPS Instruction 4700.2.[2]

While the concept was new, the objective was the same as it was in the pilot-mechanic era; that is, the objective of obtaining maximum performance from an aircraft at the least cost in manpower and material. An aircraft is a complicated and costly weapon system in today's Navy, and while weapon system readiness is of major importance, the cost to maintain an acceptable state of readiness cannot be overlooked. It was hoped that by thus centralizing various phases of work in existing facilities, the cost would be lowered by more efficient use of these facilities, and their manpower and material.

Navy Maintenance and Material Management System

With the three levels of maintenance concept in operation, it now became necessary to implement a Standard

---

[1] Ibid.

[2] U.S. Department of Navy, Bureau of Naval Weapons, BUWEPS, Inst. 4700.2, "Naval Aircraft Maintenance Program," 1962.

Navy Maintenance and Material Management System pertaining to aircraft and aviation material. After many months of intense effort by all echelons of the Navy, including on-site testing of the procedures at a master jet Air Station, the Naval Aviation Maintenance and Material Management Manual was approved and published by the Chief of Naval Operations on November 15, 1964. "The purpose of the manual was to prescribe procedures for the management of aircraft maintenance and material at Organizational and Intermediate levels of maintenance."[1]

By July, 1966, almost all Naval Air Stations, Aircraft Carriers and Fleet Aviation Units were operating under 3M. A multitude of changes have taken place in Naval Aviation since its inception, and many more will take place in the future. The one thing that does not change is the basic objective of a Naval Aviation Program, past, present, or future; that is, to be ready at any given moment to perform any assigned mission. The 3M program is an attempt to achieve this objective through better management of personnel, material and facilities.

Now that 3M has been in operation throughout the Fleet for almost a year, it is time to evaluate the system. The basic objectives of the system, i.e., "the efficient and economical utilization of human and material resources in the performance of maintenance,"[2] should now be reviewed. The

---

[1]U.S. Department of the Navy, Office of the Chief of Naval Operations, Naval Aviation Maintenance and Material Management Manual, 15 Nov., 1964, p. I-1.

[2]Ibid.

following chapters will look into the material control and weapon system costing aspects of 3M. Since the 3M procedures are not yet implemented at the depot level of maintenance, only organizational and intermediate levels will be looked at in depth. Other aspects of 3M receiving special attention in this paper are the use of rotatable pools for repairable components, use of pre-expended material, use of rapid transmission communication devices and the resultant overall efficient utilization of personnel. How are things different from what they used to be? In other words, where have we been? Where are we now? Wherein lies the future of 3M?

Much of the information for this paper was obtained by the author while serving on the 3M implementation team of Commander Naval Air Force, U.S. Atlantic Fleet from May, 1965 to May, 1966. In addition personal interviews have been held with knowledgeable Washington, D. C. military and civilian officials. A great deal of information was also obtained through letters and operating instructions received from Naval Air Station Supply Officers, and commercial air line officials.

CHAPTER II

MATERIAL CONTROL

Organization

The first step toward efficient and effective use of human resources under the 3M program was an attempt to get maintenance trained men out of the supply or service type duties, and get them working full time in their technical specialty. In addition, the Supply Department organization had to be revised in order to meet new rapid issue and delivery time frames, prescribed in the 3M Manual.[1] High priority material requirements had to be processed and delivered to the user within one hour of receipt of the request. All requirements regardless of priorty had to be delivered within 24 hours if the material requested was available anywhere on the ship or station.

A Supply Support Center concept was developed to respond to the maintenance needs. It was organized in such a way that maintenance organizations would have a single point of contact with the Supply Department. No longer would maintenance personnel have to travel all over the ship or station in quest of the material they wanted. There could be no

---

[1]Department of the Navy, Office of the Chief of Naval Operations, Naval Aviation Maintenance and Material Management Manual, OP-43C1/db, Ser. 1083P43, August 18, 1966 (latest change).

"passing of the buck" by Supply Department personnel with this single contact point. Supply personnel were now being graded on how much time it took them to deliver a part once a requirement was placed with them.

The Supply Support Center is made up of three sections; a Supply Response Section, a Component Control Section, and a Supply Screening Section. The Supply Response Section was designated as the one point of contact for maintenance material requirements. Its main duties were to accept the maintenance material requests, usually received by some means of rapid communication; prepare the necessary supply and accounting documentation; and deliver the material within a specified time frame. The Component Control Section was to maintain accountability for all repairable type components that were being processed through the local ship or station repair facilities. In addition they had the job of maintaining records on all rotatable pool items. Pool items consist of high usage, locally repairable materials that are issued on an exchange basis to a user activity. When resources are in short supply the Component Control Section's duties become extremely critical. This area of material control will be explained in depth later in this paper. The third section of the Supply Support Center is the Supply Screening Section. Their duties mainly involve the screening of locally non-repairable material, and determining if it should be readied for shipment to another repair facility or scrapped.

Accountability and Control

The introduction of a new aircraft into the Fleet involves a massive logistics effort. Months before an aircraft squadron receives its first new plane, spare parts to support it are moving to the station or ship that will support the squadron. All items are accounted for and controlled by the station's or ship's supply officer. Although most aviation repairable components are paid for out of appropriations at the Navy Department level, they are still accounted for through statistical charges until issued to an aircraft at the squadron level. Under present procedures these items are not capitalized, but rather fully costed at the time of issue.

Using 3M procedures these issues are accomplished by three methods; direct issue from normal supply department stocks, issues from rotatable pools and issues from pre-expended bin areas. A detailed discussion of accountability and control of rotatable pools and pre-expended bins will be covered later, and comparisons will be drawn to industry methods.

For a manufacturing concern, "The adequate and proper control of materials and supplies from the time production is planned until goods are ready for sale is a vitally important feature of a good cost accounting system."[1] The control of material receives even greater emphasis in the Navy 3M program. While the Navy doesn't sell its components, it does control

---

[1]Adolph Matz, Othel J. Curry and George W. Frank, Cost Accounting (2d ed., Cincinnati, Ohio: Southwestern Publishing Co., 1957), p. 107.

their movement and account for their status up to the point of issue to a user. In addition the old exchange item that the customer turns in when he receives a new item is accounted for until it is either repaired, scrapped or shipped to another activity for repair.

Living within limited resources is a way of life in all businesses including Naval aviation. The high cost and long delivery lead times of complex aviation material is making this fact more apparent everyday. Accountability and control of high cost components is now extremely critical. It is no longer possible for every squadron or maintenance shop to maintain its own back-up spares in its own spaces. All material not actually installed in an aircraft has to be controlled and accounted for. It is now even necessary to account for certain critical items that are installed on the operating aircraft. "As much care should be exercised in safeguarding and accounting for materials as is used in accounting for cash."[1]

Under the 3M procedures it is necessary that each supply activity maintain a rotatable pool of material to replace defective or malfunctioning components turned in for intermediate level repair. Material to be included in the pool must meet the following criteria: (a) be capable of repair by the local intermediate maintenance activity, (b) have application relationship to weapon systems supported by

---

[1]Ibid.

local maintenance activities, and (c) have an average organizational maintenance level removal rate of at least one per month.

The rationale behind these criteria is that the pool is self-perpetuating as long as it can repair the defective components turned in for new items. Only items that can be repaired with the skills and tools available to the local intermediate maintenance activity should be kept in the pool. If the item cannot be repaired locally, it must be processed to the proper overhaul point. All items carried in the rotatable pool must be items that are required to support the locally based aircraft. These items receive special attention and require extra control and expeditious handling. It is of little value to a local command to use personnel to repair material that won't be used locally. Pool items are also restricted from normal supply system use and their location in a rotatable pool could prevent a requiring activity from receiving that part as expeditiously as they might otherwise. Restricting pool items to those that are issued at least once a month is common sense. If an item is used less frequently than that, effort should not be wasted on it by giving it special handling in a rotatable pool.

The above criteria will be used in conjunction with the table of Aircraft Maintenance Department Repair Cycle Asset Pool Allowances, published by the Naval Aviation Supply Office.[1] This allowance table is based on repair cycle time,

---

[1]Naval Aviation Supply Office Instruction 4700.25 on "Table of Aircraft Maintenance Department Repair Cycle Asset Pool Allowances."

[illegible]

[illegible]

[illegible]

[illegible]

mean total elapsed time between removal of a component from an aircraft and the complete local repair of the item into a ready-for-issue (RFI) condition; and also on the local removal rate, which is the mean number of defective components removed from aircraft over a three-month period for which replacement RFI components were required.

Effective rotatable pools of aircraft components are one of the most important benefits of the 3M system for the local operating squadrons. Under prior programs a great deal of maintenance time was spent by squadron personnel in their efforts to repair a defective component prior to requesting a replacement from the Supply Department. Even if they could repair the item, the aircraft remained either grounded or not fully equipped until the repairs were completed. If they could not repair the item, a relatively long period of time was consumed in obtaining a replacement item. Preparation of a requisition to present to Supply for the required item took time, and transportation to and from the storage area also was time consuming.

The objective of the rotatable pool is to anticipate future requirements of locally repairable components, and to have them pre-positioned to facilitate rapid response to squadron needs. The fact that there is a local station repair capability means that local station stocks may be reduced commensurate with the average repair cycle time of each item in the pool. Under 3M, a squadron requiring a pool item is literally able to "swap" their defective item for a ready-for-issue item. The covering paper work is accomplished after the

issue is completed. Rapid issues of this nature from the rotatable pool have been made to aircraft during their pre-flight warm-up, allowing them to take off on schedule and accomplish their mission.

To keep the pool stocks in a ready-for-issue condition, full cooperation between the Maintenance and the Supply organizations is necessary. Initially, the Supply Department must procure and position the rotatable pool stocks. Then as issues are made from the pool, the squadron receiving the RFI item must insure a rapid turn-in of the defective component for repair. The Supply Department must insure that the defective item is turned in, and then expedite and control its movement into the Intermediate Maintenance Activity (IMA) for repair. The IMA then has the responsibility of repairing the item and returning it to the pool for future issue. When pool stocks are in short supply, the Supply Department has the authority and the responsibility to request expeditious handling by the IMA to prevent total depletion of the pool's stock.

When the rotatable pool stock as well as any station back-up stock of a requested item is depleted, the coordination and control procedures come to a real test. The Supply Department, through its Component Control Section, is now called on to determine the status of pool items of the type desired which are undergoing repair in the IMA. A decision must now be made as to the best way of satisfying the requiring activity's demand. Normally, the decision would be to expedite the repair of the defective component.

[illegible]

[illegible]

[illegible]

Sometimes repairs are delayed due to a requirement to obtain a bit or piece which is not available on station. When ordering off-station, it is more economical and normally faster to request a small part and complete the repair of the component, than it would be to order a new component. Just the extra shipping charges of the larger component, not to mention the potential handling damage, makes requesting the repair part the better procedure to follow. However, if the Component Control Section's status file on like items undergoing repair indicates that there is a problem in obtaining the repair part, action might be taken to order the complete component.

It can readily be seen that without proper material control being exercised by the Component Control Section, a squadron aircraft may remain grounded or not fully equipped for days, or even months. Delays could result by not alerting the IMA to expedite an item that already is in process of repair. Or, a long delay could result from ordering a repair part that is not scheduled by the contractor for delivery before ninety days.

According to Matz, Curry and Frank, materials control is designed to:

(1) Provide a supply of required materials and parts for efficient and uninterrupted operations.

(2) Maintain the investment in inventories at the lowest level consistent with operating requirements.

(3) Store materials with a minimum of handling time and

cost, protecting them from loss by fire, theft, the elements, and damage through handling.

(4) Identify and report inactive, surplus and obsolete items.[1]

The 3M concept is not in conflict with any of these statements. To illustrate the control procedures under 3M, it would be enlightening to trace a single repairable component through a transaction cycle. The transaction begins when a maintenance man determines he has a defective or malfunctioning part on his aircraft that he cannot repair. He triggers two actions. He prepares a maintenance action form, in four copies, indicating the defect discovered and simultaneously places a request with the Supply Response Section for a new item. The request for the new item is usually accomplished over the telephone or by use of a telewriter, transmitter receiver, set-up between the maintenance activity and the Supply Response Section. Depending on the priority of the request, it is then Supply's responsibility to deliver a ready-for-issue item to the requesting activity within the specified time frame.

Control of the issued material begins at the time the request is received. A multi-copy, multi-colored requisition document is prepared by Supply personnel prior to issue of the material. The requisition is annotated with the requestor's job control number, type of equipment the part is to be used

---

[1]Matz, Curry and Frank, p. 108.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

on, bureau number of the aircraft it is to be installed on, requisition number, stock number of the item issued and other identifying data. One copy of the requisition goes to the Fiscal Division for cost accounting purposes. The original copy is forwarded to main supply to up-date stock balance records. Since the item is exchangeable, that is, the replaced item must be turned in by the user activity in exchange for the one issued, control of the turn-in item is maintained by sending the white copy of the requisition to the Component Control Section, where it is held in a suspense file. The required material meanwhile is delivered to the specified delivery point. Proof of delivery is obtained on the hard back copy of the requisition and the green copy is surrendered to the user activity's representative.

If the defective component is not available, the supply representative returns the hard and yellow copies of the requisition to the Component Control Section. At this point, by means of the job control number, requisition number and stock number, the yellow and hard back copies of the requisition are matched with the white copy already in the suspense file. The hard back copy is forwarded to main supply for proof of delivery. The yellow and white copies are filed in a suspense file awaiting return of the defective component by the user activity. A yellow copy in the Component Control Section file indicates that the original requesting activity owes a defective component to the system. If 48 hours passes after delivery of the RFI component, the requesting activity

is informed of the delay and asked to take immediate action to have the defective component turned in.

When the defective item is turned in, it is accompanied by three copies of the maintenance action form that was prepared when the defect or malfunction first occurred. The original is retained by the requesting activity. The defective item is picked up from the requesting activity and delivered by Supply personnel directly to the Intermediate Maintenance Activity for screening and possible repair. The number two copy of the maintenance action form is signed by the Intermediate Maintenance Activity representative as receipt for the defective component given to them for repair action. This copy is then forwarded to the Component Control Section where it is matched, by use of the job control number, with the yellow copy of the requisition held in the suspense file.

The yellow copy of the requisition is then surrendered to the requesting activity as proof of his turn-in of the defective exchange item. The number two copy of the maintenance action form and the white copy of the requisition are matched and held in a suspense file by the Component Control Section awaiting repair action by the Intermediate Maintenance Activity. This file is reviewed daily to insure items are being expeditiously processed by the Intermediate Maintenance Activity.

After the Intermediate Maintenance Activity has either repaired the item or determined it not repairable by them, it

is returned to the Component Control Section on the number three and four copies of the maintenance action form. The Component Control Section receipts for the item on the number three copy of the maintenance action form. If the item was repaired and is now ready-for-issue, it will be returned to stock. The number four copy of the maintenance action form remains with the item showing repair action taken. The white copy of the requisition is destroyed and the number two copy of the maintenance action form is forwarded to data services for further processing. If the item could not be repaired it is forwarded on the number four copy of the maintenance action form to the Supply Screening Section for disposition.

Low value, fast moving consumable items certainly shouldn't be tightly controlled like high cost repairables. The 3M system recognizes this fact and has authorized the use of pre-expended material. These are items normally under five dollars in value, and are consumed in large quantities in day-to-day routine work. The five dollar value is an arbitrary figure and could just as well be set at ten dollars. Most pre-expended type items will fall within the five dollar range, and items of a higher value can be pre-expended by authority of the individual station's Commanding Officer. Such items would include, to name just a few, seals, rings, wire, nuts and bolts used by aircraft mechanics; and resistors, capacitors, and diodes used by electronic technicians.

All control is not lost on these items either, as the pre-expended bins, which are located in the maintenance spaces,

[illegible]

[illegible]

[illegible]

[illegible]

are maintained and replenished by Supply personnel. Costs are distributed to various aircraft types based on recorded direct maintenance hours, on a pro rata basis on a weekly or bi-weekly system of accounting. The pre-expended bin system used at the Naval Air Station, Jacksonville, Florida, very closely parallels the double-bin system discussed in Nickerson's Managerial Cost Accounting and Analysis book.[1]

The Jacksonville procedure involved the use of a single bin divided by a metal insert. In the front section were deposited, in a loose fashion, the free issue items that the maintenance man was expected to use. Directly behind in the after section a back-up stock of the same material was deposited in a plastic bag. Attached to the plastic bag was a tag containing the stock number of the items in the bag. On periodic visits to the pre-expended bin areas the Supply Department representative would visually inspect the loose bin stock, and if necessary would deposit the plastic bag back-up stock into the front bin. It was then his responsibility to reorder stock to replenish the back-up stock in the plastic bag.

If the loose stock ran out before the Supply man arrived to replenish the stock the maintenance man was authorized to break open the plastic bag and deposit its contents in the forward bin. It was the maintenance man's responsibility to place the stock number tag attached to the plastic bag inside the bag, and return the bag to the back bin. It was

---

[1]Clarence B. Nickerson, Managerial Cost Accounting and Analysis (2d ed., New York: McGraw-Hill Book Co., 1962), pp. 162-163.

then easy for the Supply man to notice when making his rounds that stock was being consumed faster than originally planned and he would make an adjustment to the level of stock he placed in the forward bin.

Quoting again from Matz, Curry and Frank, it is seen that,

> material control is accomplished through functional organization, assignment of responsibility, and documentary evidence relating to materials from the time they are requested until [they are delivered for use]. Assuming proper organization, materials control means filling in printed forms for all steps and movements in the acquisition and the utilization of all materials.[1]

This has been referred to in Navy circles as accountability from the cradle to the grave. This statement further serves to emphasize that material control, whether in government or industry, is vitally necessary. Effective controls mean efficient operations when they are applied properly.

Commercial Comparisons

Sometimes comments are heard which suggest that the military services, because they are not profit-making organizations, do not have the incentive to control material like a commercial concern. Letters of inquiry were sent to several large commercial air line companies concerning their system of costing and controlling repairable parts. A reply from United Air Lines outlined a program very similar to that utilized by the Navy under 3M.[2]

---

[1]Matz, Curry and Frank, p. 107.

[2]Letter from K. S. Hankland, Manager of Accounting, United Air Lines, San Francisco, Calif., February 15, 1967.

[illegible]

[illegible]

> [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

United Air Lines has about 25,000 kinds of recoverable parts in a maintenance operating pool inventory. These parts are a type of assembly or component which can be economically restored to a serviceable condition by repair, parts replacement, inspection and testing. A sufficient number of units are assigned to the pool to provide adequate parts supply at line stations across their system, a serviceable supply at their San Francisco overhaul base, and an in-process inventory for the overhaul shops. They also maintain a "back-up" or reserve supply in stock inventory to replace parts which are beyond repair and must be scrapped.

They maintain inventory and cost control over repairable parts as follows:

1. When an aircraft fleet is introduced or expanded, spare parts are provisioned for the operating pool and the reserve supply. The value of these parts is capitalized and placed under perpetual inventory control.

2. As overhaul shops need parts, they withdraw a unit from the serviceable parts bin at no charge to the user or to the unit under repair.

3. When a recoverable part comes in for repair, it passes through inspection where it is determined to be repairable or scrap. If repairable, it is tagged for routing to various shops. After repair, the item is routed to the serviceable bin of the operating pool.[1]

---

[1] *Ibid.* Enclosure to United Air Lines letter, see Figure 1, page 22.

Figure 1

United Air Lines Material Movement

Flow Chart

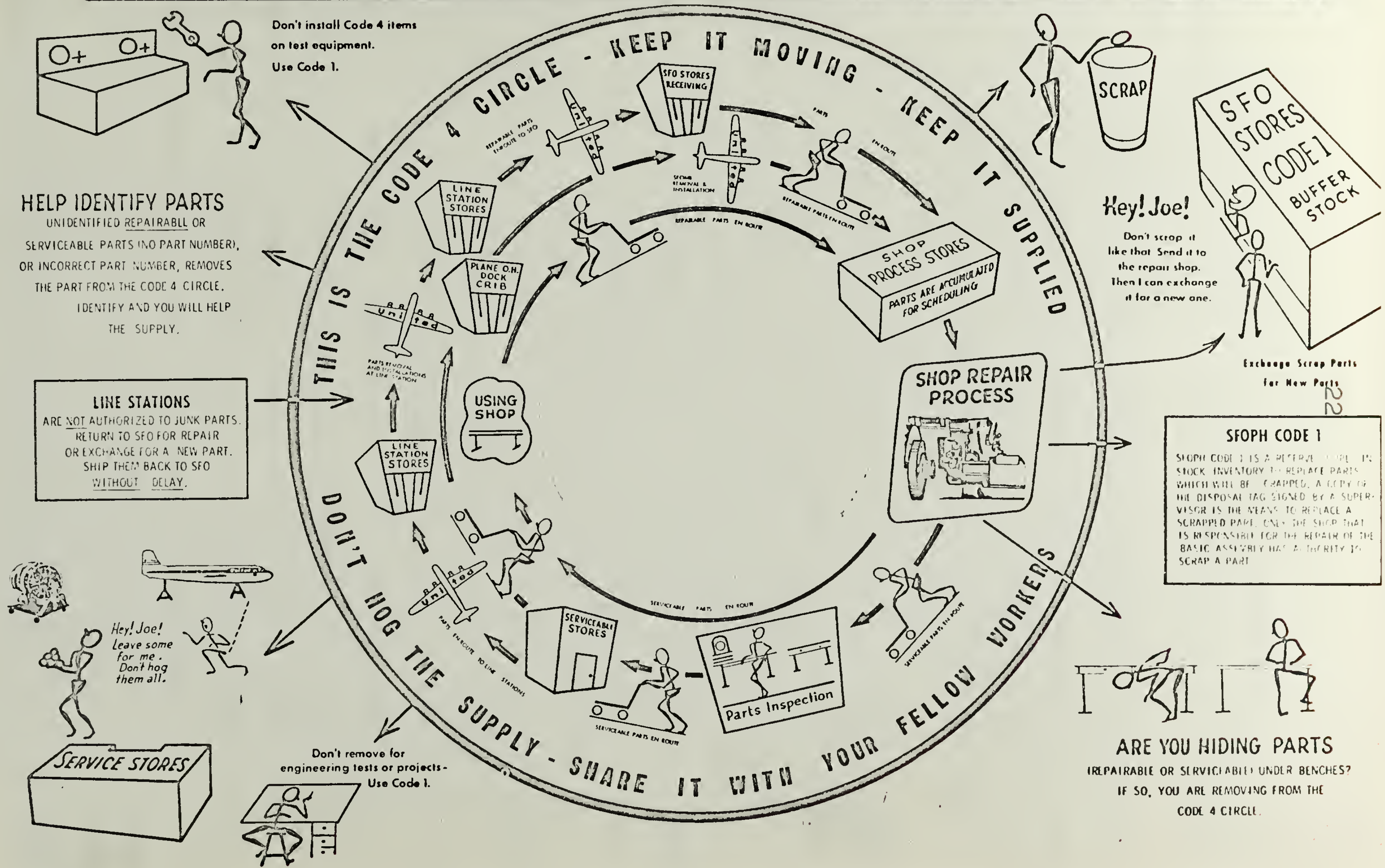
[illegible]

[illegible]

[illegible]

THE PART YOU PLAY IN PARTS SUPPLY

"Recoverable Parts" are those which we plan to restore to serviceable by scheduled expenditure of time and material. All recoverables are in the Code 4 circle, -- recoverables are identified by * on the serviceable tag and in the Stores Catalog. When in doubt, refer to the catalog. Do your part toward getting every part tagged with a correct part number.



4. If a shop scraps a unit, it requisitions a replacement from the reserve supply. The cost of the unit is charged to the home shop.

Most non-recoverable items are expensed at issue and charged to the unit being repaired. Some low cost items (e.g., nuts, bolts, screws, washers, etc.) are issued to the overhaul shops in larger quantities and are held in pre-expense bins. These costs are collected in an overhead account.

United Air Line's method of controlling items through the repair cycle is very similar to that of the Navy. Their maintenance operating pool of recoverable parts is handled almost exactly like the Navy's rotatable pool. They also maintain pre-expended bins of low cost items, as does the Navy.

While their material control procedures are similar, the costing is somewhat different from that of the Navy. United capitalizes the value of the parts in their maintenance operating pool. The Navy does not capitalize this type of item today, and under the forthcoming Resource Management System,[1] in accordance with the definition of expenses and investment costs,[2] most aviation repairables will continue to be classified as expenses. Under 3M the cost of repairing components is recorded against an aircraft type, while United Air Lines charges the costs to the unit being repaired and the repairing shop. Pre-expended material is prorated to various

---

[1]U.S. Department of Defense Directive 7000.1, Resource Management Systems of the Department of Defense, Aug. 22, 1966.

[2]U.S. Department of Defense Instruction 7040.5, Definitions of Expenses and Investment Costs, Sept. 1, 1966.

types of aircraft under 3M, while United includes these costs in overhead.

CHAPTER III

WEAPON SYSTEM COSTING

Data Collection and Material Reporting

Prior to 3M it was almost impossible to trace the costs of material usage and repair which took place at the squadron level. Total overall maintenance costs to an aircraft model could be obtained by use of various reports, but this was a slow, cumbersome and often inaccurate effort. At long last the 3M Manual has procedures set up to extend weapon system costing to the Organizational (Squadron) and Intermediate (Air Station Aircraft Maintenance Department) maintenance levels.

> The maintenance source documents, generated as a result of each maintenance action, provide basic sources of data, in terms of manhours and materials which, along with stub requisitions generated by Supply, can be translated into cost data. Further, the source documents prescribed by the Manual, are so designed that this cost data may be directly related to weapon systems (aircraft), systems and sub-systems as well as to the effectiveness of various elements of the maintenance organization.[1]

The 3M reporting procedures in addition to allowing for weapon system costing, will "relate material issues/turn-ins to weapon systems (aircraft) and components thereof, by activity and maintenance level. It will also apprise higher commands of material expenditures required to support maintenance."[2]

---

[1] Naval Aviation Maintenance and Material Management Manual, p. I-8.

[2] *Ibid.*, p. IV-36.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

The costing system is not yet operational, but it is envisioned that the actual costing will be accomplished at a central data processing facility, through utilization of source document codes. Costing at a central data bank will relieve the Fleet personnel of this task, and will allow for a more accurate pricing procedure.

Data Elements

Under the present procedures the following data elements will be required for material reporting:

*a. Job Control Number (if applicable)

*b. Type Equipment Code

*c. Work Unit Code (if applicable)

*d. Activity Issued to (Organizational Code)

e. Activity received from (Organizational Code)

f. Federal Stock Number or manufacturer's code and part number if no FSN is assigned

g. Unit of Issue

h. Quantity

**i. Total Price

*j. Repairable Item Code (if applicable)

k. Condition Code

l. Purpose Code

*m. Fund Code

n. Card Code (60, 61, 63, 64, 65, 66)

*These data elements will be provided by the maintenance organization requesting material from the Supply Activity.

**This data element applies only to SERVMART Issues (card code 66).

In order to understand the relevance of the above data elements better, the following definitions from the 3M Manual are listed.

Job Control Number (JCN) is a ten or eleven character "number" that serves as a base for Maintenance Data Reporting (MDR) and Maintenance Control procedures. The JCN allows for separate identification of each maintenance action, when necessary, and identifies the maintenance actions accomplished by the Intermediate Maintenance Activity (IMA) in support of an organization. The JCN is composed of four parts, (1) a three character alpha-numberic code which uniquely identifies the organization which originated the JCN, (2) the Julian date on which the JCN was originated, (3) a sequence number or serial number, and (4) a JCN suffix number which is added to the basic JCN to identify a sub-component repair action accomplished independently of the major component repair.

Example: AC4 4198 525

A = Atlantic

C = RCVW-4 (wing)

4 = VA-43 (squadron)

4198 = 198th day of 1964

525 = Serial number

Type Equipment Code identifies either the end item of equipment on which work is being performed or the type of equipment on which support work is being performed (aircraft, jet engines, ground support equipment, etc.).

Example: AACD

A = Aircraft

A = Attack

CD = A4-C (model and series of aircraft)

Work Unit Code is a five or seven character alpha-numberic code which normally identifies the system, sub-system, component and part of an end item being worked on.

Example: 13111

13 = Landing gear system

1 = Main landing gear left hand (sub-system)

1 = Mechanical components

1 = Fitting assembly, torque link

The remaining data elements, with the exception of the card codes, are considered self-explanatory. The card codes are intended to be interpreted at the central data processing facility, Maintenance Support Office, Mechanicsburg, Pennsylvania, to price out material issues. All material issues involving use of maintenance funds will be coded 60, 64, 65 or 66 on the local issue document. These codes, when combined with a proper condition code, will be interpreted as 100 percent charges. Code 60 will indicate a normal maintenance action charge, code 64 will indicate issues in support of Technical Directive Compliance requirements, and code 65 will indicate issues to fill Initial Outfitting Requests. Card Cod 66 will indicate a money value only issue from a SERVMART/JETMART outlet. (These are self-service shopping centers that handle low cost--high usage items.)

Card codes 61 and 63 are indicators of Intermediate Maintenance Activity action taken on a repairable type item. These codes are entered on the Maintenance Action Form (MAF) that is held in suspense by the Component Control Section until the repairable item is returned by the IMA. If the item is returned in a ready-for-issue (RFI) condition (Condition Code "A"), the MAF is coded 61. This code along with other identifying data on the MAF, such as job control number, organization code and part number/stock number will serve as a 100 percent credit to a previous issue action code 60, 100 percent charge. The charge document and credit document are matched by use of the JCN, organization code and part number/stock number which are identical, and relate to the same maintenance action.

If the repairable item is returned by the IMA to the Component Control Section recommending scrap or survey (Condition Code "H"), the suspense MAF is coded 60. This code, along with the Condition Code, results in the original code 60 issue document remaining a 100 percent charge.

If after screening, the IMA determines a defective component is beyond its capability to repair, but that it may be repaired by a major overhaul point, the item is turned in to Supply for further shipment to the designated overhaul point. This action normally takes place due to lack of skills or equipment at the intermediate level of maintenance. This type of turn-in is indicated by a card code 63 and a condition code F. The transaction results in an 80 percent credit to the original issue. The 20 percent charge is based on an

estimate that 20 percent of the items turned in to a major overhaul point after IMA screening will not be restored to an RFI condition. Future review of this estimate may indicate a need to change this charge basis.

For ease in following the costing procedures in relation to the card codes and condition codes the following transaction chart is shown.

TRANSACTION CHART

Card Code (CD. Col. 79-80)	Condition Code (CD. Col. 58)	Description of Transaction	Resultant Costing Action	Supply Dept. Action
60	A	All issues from Supply except for items in support of "Technical Directives." This includes issues of exchange items, pool items and end use items.	100% Charge	Issues
64	A	All issues of material in support of "Tech. Directives"	100% Charge	
65	A	Issues to fill initial out fittings	100% Charge	
66	A	Issues from SERVMART/ JETMART	100% Charge	
60	H	Turn-in of exchange item recommended for scrap or survey	No Charge or Credit	Receipts
60	N	Turn-in of exchange item which will not be repaired because item is in "long supply"	No Charge or Credit	
61	A	Turn-in of all "RFI" items from "IMA"	100% Credit	
63	F	Turn-in of defective components which are beyond the capability of "IMA for further shipment to designated overhaul point	80% Credit	

Figure 2

Use of Data

The potentialities of this material cost data coupled with the maintenance action and man-hour reporting now available under the 3M program are astounding. With material cost data alone, it would be possible to summarize costs by part, sub-system, system, weapon system (aircraft type), squadron, type command or Navy-wide.

Knowing the costs of material to operate a squadron of a certain type of aircraft for an extended period of time is important. Being able to itemize and cost individual part usage is also important. However, the most potentially valuable aspect of the new program is being able to combine this usage and cost data with such information as; why the part failed, how the defect was discovered, whether or not it was repairable, who made the repairs, how the repairs were made, how much time was needed to accomplish the work, and what equipment was employed.

Example: An F-4 squadron is operating in the South Pacific and is having a continuing problem with its radar, thereby reducing its operating capabilities. The ratio of maintenance hours to flight hours is increasing, while the availability of ready-for-issue radars is becoming critical.

The technical bureau reviewing this radar's maintenance difficulties by analysis of 3M data reported, on a Navy-wide basis, pinpoints a subsystem of the radar which is causing the problem. Contractor personnel are advised of the situation and quickly discover a "fix" which can solve the problem. A

technical directive is then sent out by the bureau advising all Naval activities of the corrective action to be taken. The reporting system has responded, and aircraft readiness is improved.

These types of actions are presently taking place under the 3M data collection and reporting system as it now exists. However, it is usually a procedure of backtracking that begins with a squadron having a difficult time keeping its planes in an operationally ready status. The ship or station supporting the squadron, the fleet staffs and the technical bureaus all become concerned. This is not new as these people were concerned in the past. What is new is that now under 3M it is possible to screen 3M reports previously submitted by the squadron having difficulty, and reports from other squadrons having the same type aircraft. These reports can be pulled out by aircraft type, by component and by sub-assembly by interrogating the central computer where the information is stored on tapes. This is a much faster process of reviewing a maintenance problem then ever existed before. The ultimate of course is to have this review become automatic, and corrective maintenance or supply action taken before a critical situation arises.

Integration of Systems

One of the objectives of OPNAV Instruction 4700.16 was "the development of a system for collecting, processing, analyzing and distributing feedback information that will enable line commanders and bureaus to carry out their

[illegible]

[illegible]

[illegible]

[illegible]

management function better in support of the operating forces."[1] The 3M program is a step in the right direction, but it is only carried through the Intermediate Level of Maintenance. While it is true that the Depot Level overhaul and repair facilities are collecting cost and usage information, this information is not integrated with the 3M program as of this writing. This is a gap that must be closed if accurate usage and cost data is to be obtained.

The need for a standardized and integrated data collection system was indicated in a 1964 study by a George Washington University Logistics Research Project titled, "A Survey of Information Requirements for Navy Maintenance and Material Management."[2] the study stated,

> The master file data base includes that information which must be available at a data processing center [Maintenance Support Office, Mechanicsburg,Pa.] to interact with the maintenance specific data for the production of desired maintenance [and material] reports. Many of these data exist today in total or in part at various activities within the Navy. The problems are to effect a required standardization over the many sources which currently generate or store and process these data . . . and to develop and implement control procedures.[3]

While the Navy is trying to ingegrate its management systems to be responsive to its needs, "the Department of Defense is attempting to develop a management system for its

---

[1]Department of the Navy. Office of the Chief of Naval Operations, OPNAV Inst. 4700.16, "Standard Navy Maintenance Management System," March 8, 1963.

[2]George Washington University Logistics Research Project, "A Survey of Information Requirements for Navy Maintenance and Material Management," Serial T-170, April 15, 1964.

[3]*Ibid.*, p. 15.

management systems."[1] It is obvious that management systems throughout the Department of Defense, and in particular the Navy, have gotten out of hand. Volumes of information are being gathered at all levels regarding maintenance and material costs and usage. Too much output is being realized which is not responsive to the needs of the service. There must be a move toward quality instead of quantity.

Some of the data collected under the 3M program is being effectively utilized as indicated earlier in this chapter, but most of the data is computerized and stored. Many know the source date is available and are trying to determine how to use it. Some do not even know the data is available. In a speech on February 14, 1967 to the Navy Financial Management class at The George Washington University, Mr. William A. Gill, a systems consultant from Alexandria, Virginia, indicated that before the design of any system, information requirements determination planning must take place. Certainly some information requirements were determined before the 3M system was put into effect. However, the needs of all sections involved in maintenance and material management were not integrated into the system. This does not mean that attempts were not made to bring all potential users of the 3M data into the requirements planning stage. Limited use of available data indicates, however, that if these attempts were made, they met with little success. Mr. Gill further suggested that with the

---

[1]"The Pentagon Builds a Monster," Business Week, Feb. 18, 1967, p. 198.

present organization of the Department of Defense and the Department of Navy, perhaps what is required is an Information Planning Group at a top level to cover the needs of all sections involved.

The following remarks from an Air Station Supply Officer about 3M weapon system costing exemplify the need for integration of systems.

> The Resource Management System[1] and the 3M cost concept as they are now envisioned do not appear to be compatible. not only are they not compatible, but they might appear to have been devised in mutual isolation. Labor charges as well as material charges could be included by utilizing existing 3M data. Field activities are too overloaded with fringe projects to countenance additional burdens because planning at higher level is too narrow in scope, resulting in program superimposed upon program.[2]

While this statement was true to a large extent at the time it was written, it is somewhat premature. The Resource Management System is being implemented so rapidly that initially there will be some duplication of man-hour accounting and material cost accounting. Higher authority is aware of this situation and much of the local station effort will be overcome by new computer applications and coding. It is too early to determine if the systems can eventually be efficiently integrated.

Efforts have been made at the highest levels to integrate systems and to make them compatible where possible. There is

---

[1]U.S. Department of Defense Directive 7000.1, Resource Management Systems of the Department of Defense, August 22, 1966.

[2]Quotation from Naval Air Station Supply Officer's letter in reply to author's inquiry. Anonimity of writer retained.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

a considerable time lag between inception of a plan and its fruition, as may be seen by comparing three instructions, all dealing with an "integrated logistic support," ILS, plan.

DOD Directive 4100.35 of June 19, 1964 had as its purpose the Development of Integrated Logistic Support for systems and equipments. Its two objectives were,

> (1) Military readiness is fundamental to national security and a prime responsibility of the Department of Defense. Military readiness of DOD operational systems and equipment can best be achieved through effective integrated logistic support of such systems and equipment. (2) The primary objective of this Directive is to assure that the development of effective logistic support for systems and equipments is systematically planned, acquired and managed as an integrated whole (by interlocking the elements of logistic support) to obtain maximum material readiness and optimum cost effectiveness.[1]

Two years later the integrated logistic support concept was implemented by SECNAV Instruction 4000.29.[2] It quoted the original objectives as stated in the 1964 DOD Directive and related the support planning to the life cycle of the system or equipment. Coordinated planning was to include the major elements of integrated maintenance, support personnel and equipment, technical data and publications, facilities, spares and repair parts, plus contract maintenance. Finally, efforts were to be made to judge more effectively the total-life cost of the system or equipment through "analyses of potential trade-offs between reliability and maintainability requirements, and alternative logistic support methods."[3]

---

[1] U.S. Department of Defense Directive, 4100.35, Development of Integrated Logistic Support for Systems and Equipments, June 19, 1964.

[2] SECNAV Inst. 4000.29 of August 19, 1966, "Development of Integrated Logistic Support for Systems and Equipment."

[3] Ibid., p. 2.

[illegible]

[illegible]

[illegible]

[illegible]

Ibid., [illegible]

In August, 1966, NAVMATINST 4000.2 was published as a guide to integrated logistics support planning.

> There are a number of other guides, directives and programs which either include or significantly affect features of integrated logistic support planning. It is imperative that the AM [Acquisition Manager], in establishing a plan for ILS, know of these related matters and that he utilize them where possible. It is particularly essential that other activities be compatible with the ILS process and decisions made therein.[1]

One of these related matters referred to is the Navy Maintenance and Material Management System (3M). It is a tool that the acquisition manager must be aware of, and its information gathering techniques should be exploited and expanded where necessary to arrive at the best procurement decisions.

Life Cycle Costing

Weapon system costing in its broadest sense is involved with all costs from the equipment design stage to the survey or disposal stage. The 3M program as presently structured is capable of providing, with minor changes, the total costs of repair and maintenance of aviation equipment. This includes the cost of technical labor and spare parts actually consumed in repairs. It will be illustrated later that these repair costs consume a large proportion of the total program costs of a piece of equipment.

The total program costs are better known as life cycle costs, and can be defined as "the sum of acquisition costs, installation costs, operating costs, and what have been called

---

[1]Naval Material Command Instruction 4000.20, "Integrated Logistic Support Planning Procedures," August 19, 1966, p. 12.

[illegible]

> [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

---

[1] [illegible]

logistics or support costs."[1] A study for the Department of Defense by Collins Radio Company on life cycle costing points out the importance of the life cycle logistics costs. They state that these costs are made up of six elements: facilities, test equipment, spare parts and technical services actually consumed in repairs, maintenance training, and data.

> Fundamental to the prediction of support costs, as a factor in life cycle costing, is the recognition that these logistic elements are not independent of one another. They interact extensively and any prediction of their costs requires a clear definition of the total support plan.[2]

The technical service element of life cycle logistics costs should be classified as the most critical area, because this is where the largest amount of dollars is consumed. Fortunately, the 3M program is equipped to report accurately the two prime variables of the cost of technical services. The first is <u>Equipment Reliability</u>, i.e., the mean time between failures (MTBF). The second is <u>Maintainability</u>, the characteristic of design that determines the relative ease with which a piece of equipment can be restored to service after a failure. This is expressed in mean time to repair (MTTR) or mean time per maintenance action (MTMA). "The time to accomplish each repair may be equally as important as the frequency of failure in determining the cost of technical services."[3]

---

[1] Collins Radio Company, "Life Cycle Costing," A Study prepared for the Department of Defense, August, 1966, p. 1-1.

[2] <u>Ibid</u>.

[3] <u>Ibid</u>., p. 2-1.

Under the new integrated logistic support concept it will be the government's job to evaluate the life cycle cost proposals of the contractor. The data collected under the 3M reporting system will be of great assistance in this evaluation.

Mr. Robert H. Charles, Assistant Secretary of the Air Force, in a June, 1964, speech said,

> To construe cost effectiveness in the narrow sense of buying the least expensive article is a total misconception of that term. Getting the right equipment comes first in matters of national defense; and we will almost surely err if we blindly adhere to a policy of buying at the lowest price without consideration of all the factors invloved.[1]

These factors would include feasibility studies, research, development, design and production, and all support, training and operating costs generated by acquisition of the equipment.

An example of life cycle costs in relation to selling price was given by the Collins Radio Company in its DOD study.

> A total of about 7,000 AN/GRC-27 (UHF Tranceiver) systems were procured at a maximum cost level of about $6,000 each. Based on yearly maintenance costs of about $10,000/year/equipment, the 10-year maintenance cost per equipment was $100,000, or about 16.5 times the initial purchase price. (Ten-year costs of maintaining electronic equipment ranges from 6 to 290 times the initial purchase price; per various sources.)[2]

The above figures were gathered by visiting six Air Force operational sites and various other Air Force installations. Other equipment under different operating conditions will vary in their life maintenance cost versus procurement price ratios. However, a ten-year maintenance cost factor of

---

[1]Speech by the Assistant Secretary of the Air Force, June, 1964, "Life Cycle Costing in Equipment Procurement."

[2]Collins Radio Company, pp. 3-4.

[illegible] in 1952 the Air Force [illegible] percent of the [illegible] was 95 percent [illegible].

[illegible] of the Air Force, [illegible], 1957, [illegible]),

> [illegible]

these [illegible] development, design and production, [illegible] and operating [illegible] of the equipment.

An example of [illegible] selling price [illegible],

> A total of about [illegible] of about $2,000 [illegible] of about $15,000 [illegible] equipment, [illegible] was $150,000, [illegible] initial purchase price. [illegible] electronic equipment [illegible] initial purchase price [illegible].

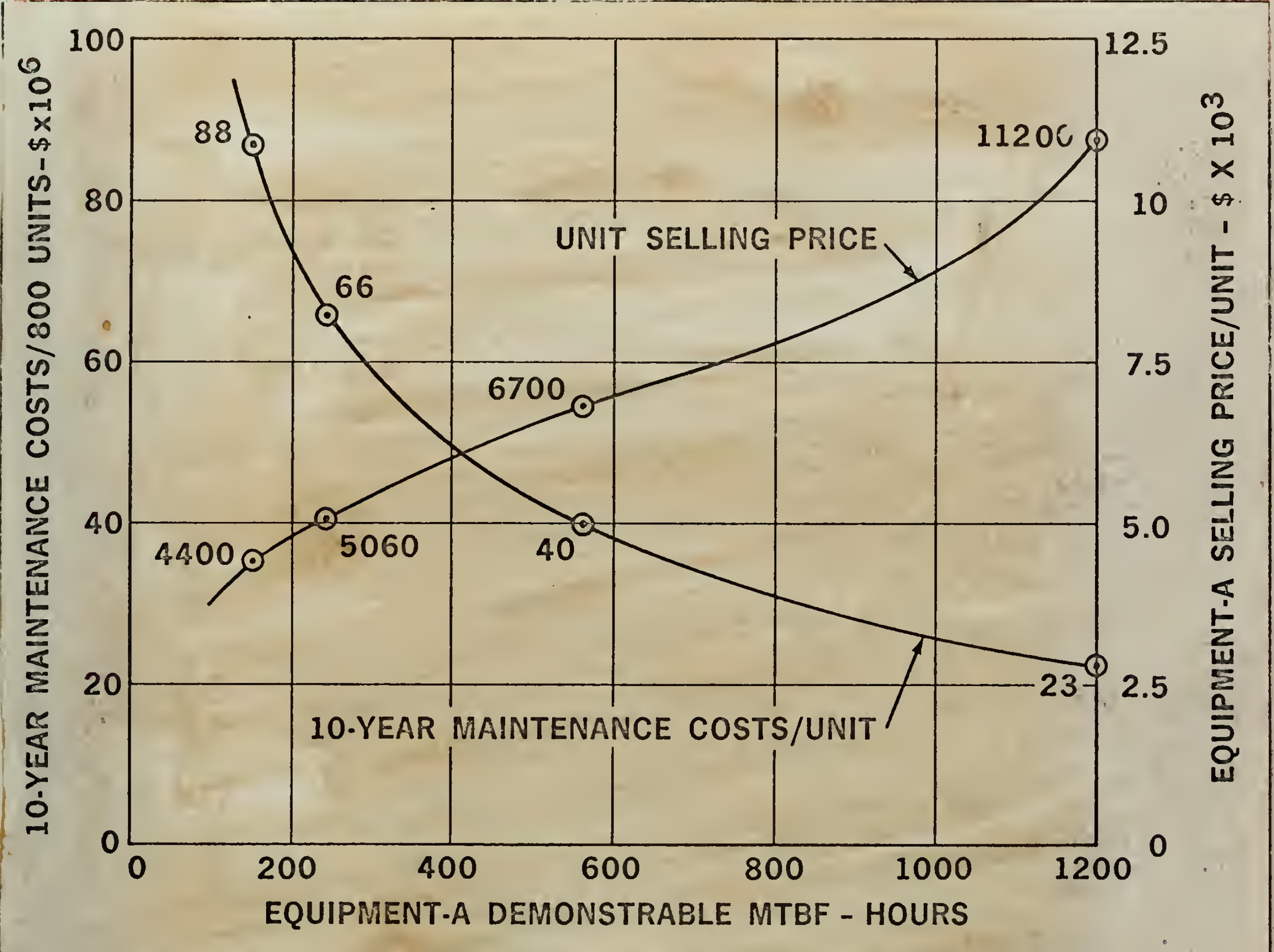
[illegible] air- [illegible] Air Force [illegible] will [illegible] procurement price ratios. [illegible] range of

---

[1] [illegible] of the Air Force, [illegible] 1957, [illegible] in procurement [illegible]."

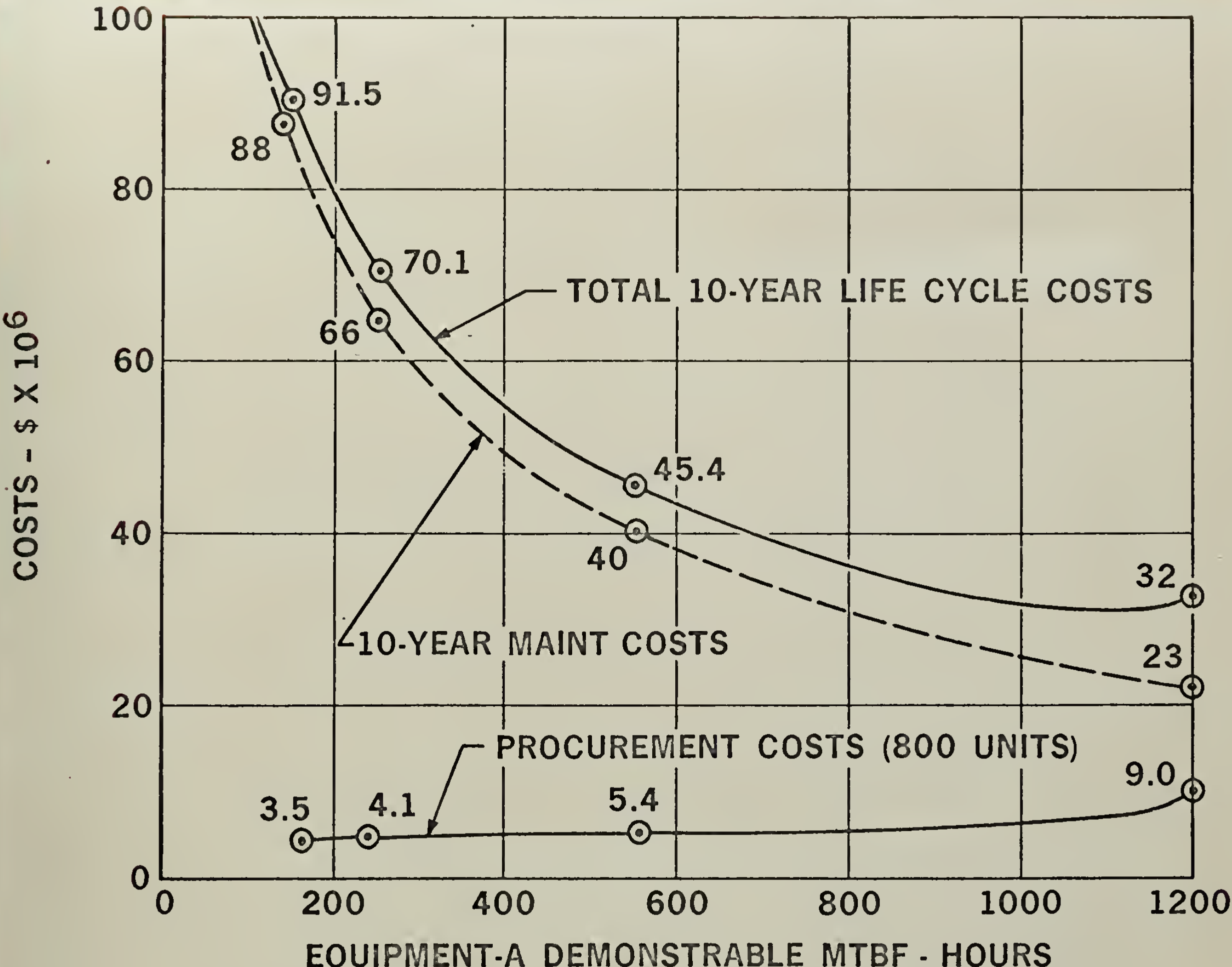
[2] [illegible], pp. [illegible].

20 times purchase price is considered sufficiently representative, and was used by Collins in constructing the following two charts.



RELATIONSHIPS OF SELLING PRICE AND MAINTENANCE COSTS TO EQUIPMENT MTBF

Figure 3



RELATIONSHIPS OF QUANTITY (800) PROCUREMENT COSTS, LIFE CYCLE (10-YEAR) MAINTENANCE COSTS, AND TOTAL PROGRAM COSTS TO EQUIPMENT MTBF BASED ON AN/GRC-27 MAINTENANCE COST FACTORS

Figure 4

Chart I graphically shows the effects of equipment reliability. As the mean time between failures (MTBF) increases, the life cycle costs per unit drop dramatically. The unit selling price increases significantly as MTBF increases, but its total effect on life cycle costs is minimal when compared to the total maintenance costs. The cost of maintenance for a ten-year period for 800 units with (demonstrable) MTBF requirements of 150 hours is about $88,000,000; the cost with an MTBF requirement of 1,200 hours is about $23,000,000. Equipment selling price increased from $4,400 to $11,200 each over this range.

Chart II emphasizes that total ten-year life cycle costs are made up of a relatively small proportion of procurement costs, and a relatively high proportion of maintenance costs. It is therefore easy to observe the tremendous cost savings that accrue when high reliability equipment is procured.

> For the example used, increasing MTBF by a factor of 8 and the selling price by a factor of 2.5 cuts total program costs for a ten-year period for 800 units from about 90 million dollars to about 30 million dollars. Additional savings from increased mission effectiveness and reduced catastrophic failures, involving loss of aircraft, vehicles, weapons and human lives, are also attributable to higher reliability.[1]

The Collins study did not make an attempt to compute these values.

---

[1] *Ibid.*, pp. 3-8.

[illegible]

[illegible]

> [illegible]

[illegible]

[illegible]

CHAPTER IV

PERSONNEL

Proper Utilization of Skills

One of the more important aspects of material control and weapon system costing is the effective and efficient utilization of personnel.

> Two laws of physics apply equally well in managing people. These are Newton's third Law of Motion, which says that, 'For every action there is an equal but opposite reaction,' and the Law of Inertia, which says, 'A body at rest tends to remain at rest; a body in motion tends to remain in motion.' Both of these principles hold equally true in dealing with employees.[1]

The Navy has people who are in perpetual motion, always moving and doing something, but many times their actions only result in wasted effort. Someone else has to pick up the ball, undo the previous damage, and begin again. Many other personnel are just "warm bodies". They have no initiative of their own and rarely think out their actions. It is difficult to get them started on a job, and changing their methods once they are ingrained is almost impossible. Hopefully, a good management system can provide means for effectively utilizing all types of workers.

---

[1]Leon C. Megginson, "The Pressure for Principles: A Challenge to Management Professors," Current Issues and Emerging Concepts in Management, ed. by Paul M. Dauten, Jr. (Boston: Houghton Mifflin Co., 1962), p. 49

CHAPTER V

[illegible]

[illegible] Utilization of [illegible]

One of the more important aspects of [illegible] [illegible] and [illegible] [illegible] [illegible] in the [illegible] and efficient utilization of personnel.

> [illegible][1]

[illegible]

---

[1] [illegible]

One of the basic premises of the 3M program is that maintenance personnel will be utilized primarily in actual maintenance work. Supply support and cost accounting functions are to be handled by "supply type" people. There is no economic justification for having a highly skilled technician involved in duties that take him away from his primary maintenance work.

With this principle in mind, several things took place under 3M to relieve the maintenance man of unnecessary duties. The data collection and processing procedures were devised to limit maintenance personnel participation.

> The primary purpose of data collection in this management system is to insure that basic data generated by maintenance personnel are recorded once, and only once, and that the system (not the maintenance activity) thereafter provide information to all who have need for it in such forms as may be useful.[1]

Prior to 3M there were frequent requests to squadrons, ships or air stations to provide maintenance data to higher commands. There were questions such as, "How many p3A wheels did VP-30 use in the last month and what was the primary cause of failure?" Answers to these questions can now be provided by the system through use of data already forwarded to the central data bank. The maintenance man should not have to page through his old maintenance records to dig out this type of information anymore.

Under 3M the maintenance technician has been relieved of the task of picking up his material needs. In addition,

---

[1]Naval Aviation Maintenance and Material Management Manual, p. I-8.

it is no longer his job to turn in the defective repairable items to the Supply Department. Pick-up and delivery service is now provided by the station Supply Department. This keeps the maintenance man on the job of maintaining his own aircraft or repairing defective equipments, thereby increasing his productive output. The added service of pick-up and delivery required a reallocation of personnel. Centralized funding and expanded and improved Supply/Maintenance communications were implemented and contributed greatly to the more effective use of personnel.

The job of financial control of funds for material required in support of weapon system maintenance was removed from the squadron level. The control of maintenance funds for all supported squadrons and the Aircraft Maintenance Department became the responsibility of the air station. Storekeepers who previously worked within each squadron maintaining accounting records are now released for duties within the air station Supply Department. Since the requisition preparation for maintenance material is now centralized in the Supply Support Center, and maintenance funds are controlled centrally on-station, additional personnel have become available to provide the extra service to the maintenance organizations.

Improved Communication Systems

Probably the greatest time saver between Maintenance order time and Supply delivery time has resulted from the improved communication system. With the responsibility of maintenance funding shifting from the squadron to the station,

[illegible]

[illegible]

[illegible]

[illegible]

and the requisition preparation being accomplished by the Supply Department, it has become easy to improve requisition transmitting procedures. One such improvement recently put into practice is the transmission of supply requisitions by telewriters.

An analysis of time factors between order time and delivery time, aboard Naval Air Stations and Aircraft Carriers, of material requirements led to a new approach in requisition processing. Too much time was being consumed by the maintenance man in the preparation and transporting of supply documents.

Under the old procedures it was necessary for each fleet squadron to request their material requirements on a six part requisition DD Form 1348. The requisition was typed or written in legible ball point pen by the requiring squadron storekeeper, he retained one copy for his files. The remaining copies were then delivered to the Supply Support Center for issue or further processing by Supply Department personnel. If the item is available at the Supply Support Center (auxiliary store), the material was issued on the number 2 and 4 copies of the DD Form 1348. The remaining copies were forwarded to main supply for recording of the issue on the stock records, and forwarding of the fiscal copies to the Comptroller Department for recording of the charge.

The problem of wasted time is not too serious if all requirements are filled by the Supply Support Center. This only involves the delay of the squadron personnel while they

hand carry the requisition from their spaces to the Supply Support Center, which is within close proximity to most squadrons, and return with the material to their working spaces. Time delay and inefficient use of personnel is really apparent when material requirements are not available at the Supply Support Center. It is then necessary for the squadron storekeeper or Supply Support Center personnel to carry the DD Form 1348 to the main supply building for further processing. A flow chart of this procedure is shown on Figure 5.

With the advent of new automatic transcribing equipment, now available through Federal Supply Schedule contracts, the old procedures for processing requisitions was considered both expensive and inefficient. Transmitting and receiving equipment, known as telewriters, are now available on a six week delivery basis. The operation of the equipment is very simple, and little instruction for its use is required. Using a special ball point pen type device, transmission is accomplished by writing on a continuous roll or printed form connected to the transmitter. The written information is then transmitted by telephone wire to the desired receiving equipment. Normally, already available telephone lines are utilized for the transmission lines.

With the implementation of the Standard Navy Maintenance and Material Management System, (3M), all aviation maintenance costs are accounted for by the supporting ship or station. It is no longer required or desired that operating squadrons account for maintenance funds at their level. Therefore documentation of maintenance requisitions no longer has to flow

[illegible]

[illegible]

[illegible]

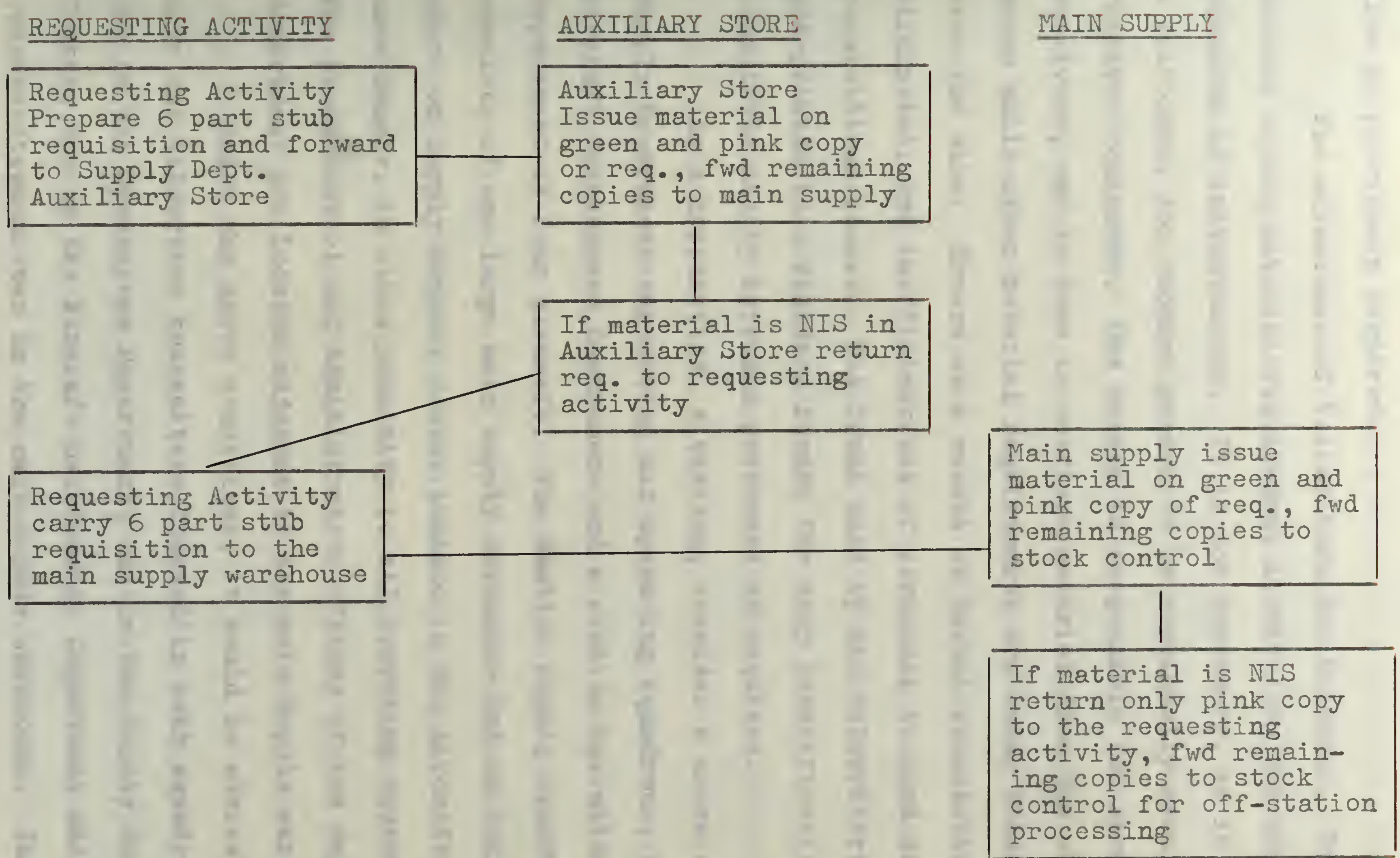


Figure 5

SIMPLIFIED REQUISITION FLOW CHART

flow as previously required.

The advantages of telewriters are numerous. Transmission of the material requirement direct from the using squadron is instantaneous. It is not necessary, as it is with a telephone, for another person to be continually manning the receiver equipment. One person is responsible for several receivers, and is free to retrieve material from the storage areas while other material requirements are being transmitted over the wire. Errors as a result of verbal translation are eliminated, and inefficient use of personnel to hand carry requisitions ceases. The forms used by the telewriters are pre-printed in a standard format for easy identification and compatible use by keypunch personnel as required.

As a hypothetical situation, consider a shore station Supply Department supporting six operating squadrons, a station Aircraft Maintenance Department and a station Operations Department of four aircraft. The station Supply Department consists of one large main supply warehouse and an auxiliary store or Supply Support Center located in the Aircraft Maintenance hangar, in close proximity to all operating squadrons. The stock control and administrative offices of the Supply Department are located adjacent to the main Supply warehouse.

Under the above conditions, it would be advisable to have one telewriter transmitter located in each squadron space, one in the Operations Department, one in the Supply Support Center, one in the Aircraft Maintenance Department and one receiver/transmitter in the main supply warehouse. In addition,

the Supply Support Center would have two receivers connected to all other area transmitters. (Figure 6) This would be a minimum configuration, with experience dictating further expansion of equipment.

With this arrangement it is now possible for a material request to come into the Supply Support Center from a using squadron or department, be filled by the Supply Support Center, or be retransmitted to the main supply warehouse for action. In other words, if material is available anywhere on station action is initiated to deliver it to the using department or squadron based on their initial transmission over the telewriter to the auxiliary store.

With the utilization of telewriters, the Supply Support Center (auxiliary store) is the single point of contact with the Supply Department for all aircraft maintenance requirements. No longer do maintenance personnel have to travel all over the ship or station in quest of the material they want. There can be no "passing of the buck" by Supply Department Personnel with this single contact point. Maintenance personnel could be assured of expeditious service as Supply Department personnel, operating under the 3M system, are now being graded on how much time it takes them to deliver a part once a requirement is placed with them.

Telewriters or electrowriters of similar design and cost are now being produced by the Telautograph Corporation and the Victor Comptometer Corporation. Both companies' equipment are listed on authorized Federal Supply Schedule

[illegible]

[illegible]

[illegible]

[illegible]

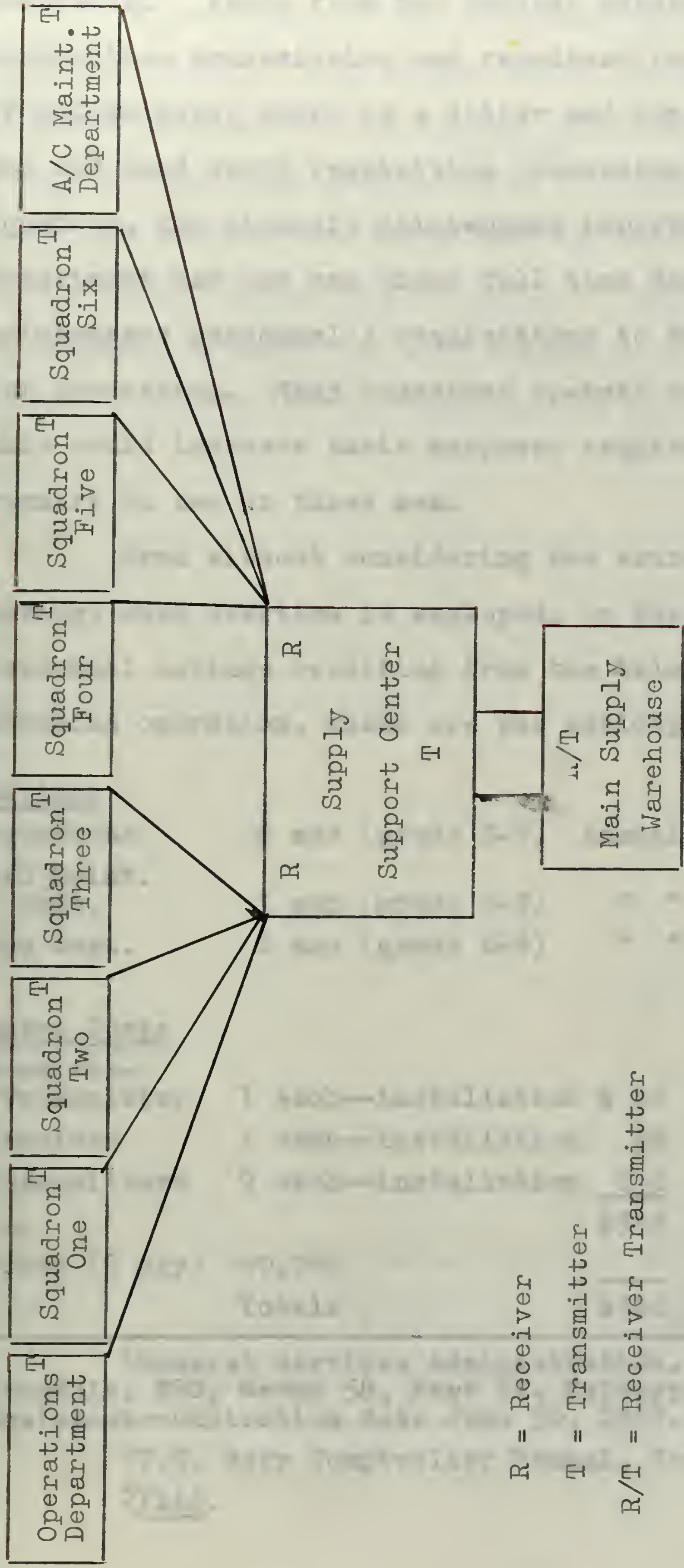
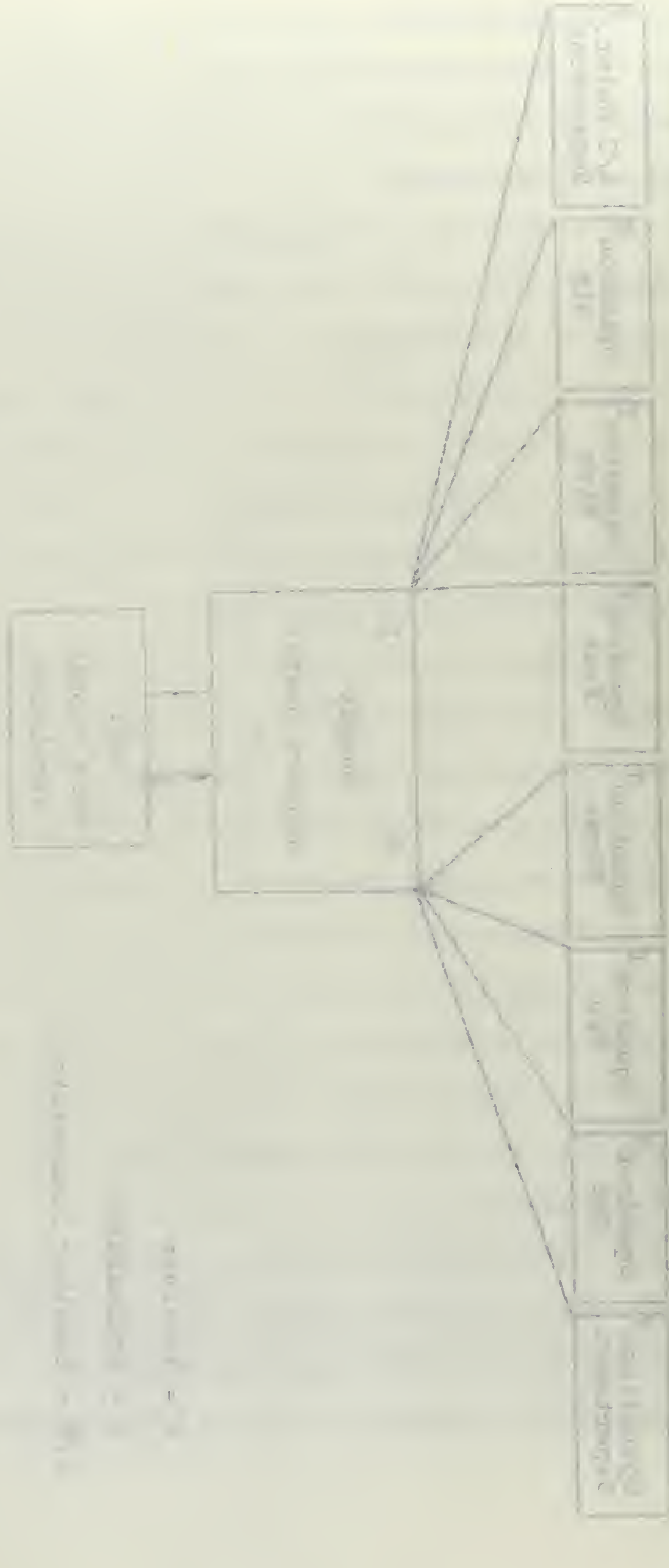


Figure 6

PROPOSED TELEWRITER PLAN



Contracts.[1] Aside from the obvious advantages of speed of requisition transmission and resultant rapid response, by use of telewriters; there is a dollar and cents savings. Under the old hand carry requisition processing procedures each squadron, the Aircraft Maintenance Department and the Operations Department had one man whose full time duty was to carry maintenance personnel's requisitions to the Supply Department for processing. Many squadrons operate around-the-clock so this could increase their manpower requirement for requisition runners to two or three men.

Even without considering the extra manpower cost savings when overtime is employed, or the possible Supply personnel savings resulting from the telewriter receivers unattended operation, these are the anticipated dollar savings:

Savings			
Squadrons	6 men (grade E-3)	Annual Wages	$18,420[2]
A/C Maint. Dept.	1 man (grade E-3)	" " "	3,070
Ops Dept.	1 man (grade E-3)	" " "	3,070
			$24,560

Extra Costs				
Receiver-Transmitter	1 each--installation	$ 40	Annual Rental	$ 528[3]
Receiver	1 each--installation	56	" " " "	600
Transmitters	9 each--installation	252	" " " "	2,700
		$348		$3,828
Forms (2 ply)	40,000		Annual Cost	$ 648
	Totals	$348		$4,512

[1]General Services Administration, Federal Supply Schedule, FSC, Group 58, Part II, Teletype and Facsimile Equipment--expiration date June 30, 1967.

[2]U.S. Navy Comptroller Manual, Volume III, para. 035750.

[3]*Ibid.*

These figures show an annual operating cost reduction of over $20,000. This figure would, of course, have to be tempered somewhat by the installation costs of $348, which could be increased substantially if the present telephone lines could not be used for the telewriter installation. It is also necessary to recognize that with the present overall personnel shortages, it would still be necessary to utilize the manpower saved by the telewriter installation in other capacities.

CHAPTER V

CONCLUSIONS

While some of the analysis of the control systems employed by the Standard Navy Maintenance and Material Management System were quite detailed in Chapter II, it clearly shows that there is an effective local accountability and control system. It is effective because the repairable aviation component is never lost track of throughout its life on station. It could be more effective Navy-wide if the same controls were applied on material shipped off station to a major overhaul and repair facility. As of this date the overhaul and repair facilities do not operate under the 3M system. While they do have a material control system of their own, it is probable that one uniform system Navy-wide would be more effective. Plans are now being formulated to bring all of the major overhaul and repair activities under the 3M system in the future.

While sixty to seventy percent of all defective components are repaired at the organizational and intermediate levels of maintenance, thirty to forty percent are forwarded to a depot level maintenance activity (O&R) for further processing. This is the point where the chain of events breaks. Since the depot level activities are not operating under 3M procedures, it becomes very difficult if not impossible to tie any depot maintenance action back to the original removal

CHAPTER V

CONCLUSIONS

While none of the analysis of the [illegible] employed by the Standard Navy Maintenance and Material Management System [illegible] in Chapter IV), it clearly shows that there is no effective [illegible] and control system. It is [illegible] [illegible] it would be much [illegible] applied as [illegible] and [illegible] facilities [illegible] that the uniform system [illegible] would be [illegible] [illegible].

While [illegible] requirements [illegible] levels of maintenance, [illegible] to a lower level [illegible]. This is the point [illegible] where the above [illegible] procedures, it becomes very difficult [illegible] the [illegible] the original [illegible]

of a part from an aircraft. It is extremely important to expedite the closing of this information gap, in order to fully realize the benefits of 3M.

The 3M system can be the main tool for arriving at the life cycle cost of aviation material. Since the major portion of a component's life cycle costs are tied to its repair costs, a standard cost control system must be maintained through all levels of maintenance. A smooth flow of material and accurate transition of paperwork must be made between organization and intermediate maintenance levels, as well as between intermediate and depot levels.

The Integrated Logistic Support Planning concept and the Life Cycle Cost concept have emphasized new avenues to follow to increase cost effectiveness. Concomitantly with the cost effectiveness benefit is the resultant improvement in combat readiness.

Life cycle costing looks beyond the purchase price of an item. It is folly to purchase the component that costs the least only to have it constantly in need of repair. Cost effectiveness cannot be measured by purchase price alone, which for most electronic components is a small percentage of the item's total life costs. Life cycle cost analysis can provide methods for assuring lower total cost of ownership. This is where true cost effectiveness can be measured, and if the two items that most influence life cycle costs, maintainability and reliability, are improved; so combat readiness is improved. Reliable equipment that seldom fail, and ones that can be

of a year from installation. [illegible] extremely necessary to expedite the planning of this maintenance team in order to fully realize the benefits of it.

The P.M. program [illegible] its [illegible] at the life cycle cost of [illegible]. Since the major portion of a Government's life cycle costs goes to the support costs, a dynamic data network on the basis of [illegible] through all levels of maintenance. A smooth flow of technical and economic information of operational data [illegible] between headquarters and intermediate [illegible] as well as between depot, [illegible] and [illegible] levels.

The Integrated Logistic Support Planning concept and the life cycle cost concept have [illegible] and [illegible] to [illegible] in [illegible]. [illegible] with the cost effectiveness [illegible] is the [illegible] importance to combat readiness.

With their [illegible] beyond the [illegible] of an item. It is [illegible] the [illegible] cost [illegible] the level only [illegible] of [illegible] of repair. [illegible] effectiveness [illegible] the [illegible] of [illegible] units, which [illegible] of the [illegible] life cycle [illegible] the [illegible] cost of ownership. This is [illegible] that [illegible] can be [illegible] and if the [illegible] reliability and [illegible] is improved. [illegible] that can be

easily and rapidly restored to operation if they do fail, are the major contributors to high readiness factors.

Maintenance manhour requirements in relation to flying hours seem to increase with each new aircraft that the Navy receives. Thirty maintenance manhours to every flying hour is not unusual today. In fact, recent monthly reports indicate a ratio as high as forty to one for the A6A and 100 to one for the RA5C aircraft.[1] Maintainability (MTTR) and reliability (MTBF) are becoming increasingly important measurements. Procurement specifications and the evaluation of proposals for both of these factors must become more accurate and meaningful.

The 3M system is structured to provide maintainability, reliability and repair cost data. With maintenance time and costs skyrocketing due to sophisticated electronic equipment on today's aircraft, the necessity to control and evaluate this type of data becomes increasingly important. Future procurement contract specifications must be based on facts derived from an accurate measurement system. Once a contractor accepts the specifications in a contract, an evaluation and review of his compliance concerning reliability and maintainability factors of his equipment is required. The 3M system is a tool that can meet these needs.

The horizons appear bright for 3M in the future. Limited results are beginning to emerge from the masses of data that are gathered and stored on tape at the central data bank.

---

[1]Random samples of various squadron monthly 3M maintenance manhours per flying hour and sortie reports.

A push is needed on the analysis side at the highest level. Information is available to cost out a part or a component, and relate these costs to a type of aircraft, squadron, ship, or station. Reliability and maintainability information is available for use by the technical offices and the procurement sections. Usage information is available for provisioning and re-provisioning studies.

Some offices do not want to use the data because they mistrust the input accuracy. Others hesitate to try a new system due to ingrained resistance to change. Still others are not familiar with what benefits they may derive from 3M. Too much time and money have gone into 3M to let it lie idle. Valuable information is stored waiting for analysis. The 3M program has provided management with another tool for better decision making. The time to activate that tool is here.

The aviation 3M program is now entering a critical evaluation period. The 3M program, both in aviation and aboard ships has expended over fifty-four million dollars during its implementation stage. Funding for the program in the future will be based on quantifiable dollar savings.

Quantifiable results of 3M are difficult to obtain at this stage, as most of the effort has gone into training and getting the program implemented. One of the known dollar savings, which gives some indication of the potential of 3M, was recorded only recently. Two million dollars were saved by purging an E2A aircraft provisioning load for five aircraft carriers. Past usage reported through the 3M reporting system

a basic inventory [illegible]

interesting [illegible]

and volume [illegible]

[illegible]

available for use by the [illegible]

Statistics. Gauge information [illegible]

pre-construction studies.

These offices [illegible]

[illegible]

evaluation period. [illegible]

[illegible]

was compared with the carrier load requirements previously compiled, and quantities put aboard of certain items were reduced and others increased. The end result was an updated load list, with a resultant dollar savings of two million dollars.

It is now possible for a Naval Air Station or an Aircraft Carrier to be much more self-sufficient than they ever have been in the past. Items that previously took weeks and sometimes months to receive from the system can now be generated by the repair of the defective component at the local station Intermediate Maintenance Activity. Hoarding of system assets by squadron personnel has been eliminated. All assets are now on the records of an accountable officer. The Navy is getting the most utility out of its limited assets now that they are under proper control.

Because of the better record keeping procedures, the system can now accurately determine past usage and apply it to present-day needs. Two overseas Air Stations were recently outfitted to provide supply support for P3A aircraft, based solely on 3M data generated by operating squadrons reporting their usage to the central data bank. The information was obtained rapidly, and probably was the most accurate usage data ever obtained for this purpose. The guess work of previous outfittings was eliminated, and the material positioned overseas was determined by actual past usage.

Probably one of the greatest values that has come out of the 3M system is the feeling of cooperation that exists

between supply and maintenance personnel. Responsibilities are much more clearly defined. Controls become meaningful when a person can be held responsible for his action or lack of action. Therefore, when controls are effective, performance is maximized. When performance is maximized within an efficient system, costs are minimized.

The maintenance man is now in his shop working on a component or out on his aircraft doing necessary maintenance. He no longer wastes time traveling to and from the Supply Department spaces in search of required parts. He is no longer burdened with preparing the documentation of a requisition for his material requirements. This is now done for him by Supply Department personnel. Supply personnel deliver the required material to his working area, and even pick-up his defective repairable components. Supply then takes action to have them repaired so they will be ready for his use in the future.

The 3M system is here. Evaluation and refinements will continue, as aviation is dynamic and change axiomatic. The system should be extended to the depot level of maintenance as soon as practicable, and the weapon system costing procedures need to be implemented. Any system to be successful needs the backing of management at all levels. An "I don't care or I don't know" attitude of a supervisor or manager will permeate to the lowest level worker.

A great deal of effort went into the education of the maintenance and supply working level personnel. It is now time

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

to educate the higher levels, or at least make them aware, of 3M's potential. Cost effectiveness is the by-word of the Department of Defense. The 3M program will prove itself if used to its full potential.

BIBLIOGRAPHY

Public Documents

U.S. Department of Defense Directive, 4100.35. Development of Integrated Logistic Support for Systems and Equipments. June 19, 1964.

U.S. Department of Defense Directive 7000.1. Resource Management Systems of the Department of Defense. August 22, 1966.

U.S. Department of Defense Instruction 7040.5. Definitions of Expenses and Investment Costs. September 1, 1966.

U.S. Department of the Navy, Office of the Chief of Naval Operations, OPNAV Inst. 5400.5. Naval Aircraft Maintenance Program. October, 1959.

________. Naval Aviation Maintenance and Material Management Manual. November 15, 1964.

________. OPNAV Inst. 4700.16 Series. Standard Navy Maintenance System. March 8, 1963.

________. Naval Aviation Maintenance and Material Management Manual. OP-43C1/db, Ser. 1083P43. August 18, 1966.

U.S. Department of the Navy, Bureau of Naval Weapons, BUWEPS Inst. 4700.2 Series, Naval Aircraft Maintenance Program. October, 1964.

U.S. Department of the Navy, SECNAV Instruction 4000.29. Development of Integrated Logistic Support for Systems and Equipments. August 19, 1966.

U.S. Department of the Navy, Naval Material Command, NAVMAT Instruction 4000.20. Integrated Logistic Support Planning Procedures. August 19, 1966.

U.S. Navy Comptroller Manual, Volume III.

Naval Aviation Supply Office Instruction 4700.25. Table of Aircraft Maintenance Department Repair Cycle Asset Pool Allowances.

General Services Administration. Federal Supply Schedule, FSC, Group 58, Part II, Teletype and Facisimile Equipment, expiration date June 30, 1967.

Books

Anthony, Robert N. "Characteristics of Management Control Systems," in Management Control Systems edited by R. N. Anthony, John Deardon and R. F. Vancil. Homewood, Ill.: Richard D. Irwin Inc., 1965.

Gregory, R. H., and Van Horn, R. L. Automatic Data Processing Systems. Belmont, Calif.: Wadsworth Publishing Company Inc., 1964.

Matz, Adolph, Curry, Othel J., and Frank, George W. Cost Accounting. 2d ed. Cincinnati, Ohio: Southwestern Publishing Co., 1957.

Massie, Joseph L. Essentials of Management. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1965.

Megginson, Leon C. "The Pressure for Principles: A Challenge to Management Professors," Current Issues and Emerging Concepts in Management. edited by Paul M. Dauten, Jr. Boston: Houghton Mifflin Co., 1962.

Mettler, Armond L. "The Systems Study," Systems and Procedures edited by Victor Lazzaro. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1959.

Nickerson, Clarence B. Managerial Cost Accounting and Analysis. 2d ed. New York: McGraw-Hill Book Co., 1962.

Articles and Periodicals

"The Pentagon Builds a Monster," Business Week, Feb. 18, 1967.

Interviews

Chief of Naval Material. Personal Interview with Col. E. M. Downing, USAF, Technical Advisor to the Navy Maintenance and Material Management System Staff, October 21, 1966.

Chief of Naval Material. Personal Interview with LtJG S. H. Carter, Assistant Supply System Analyst, the Navy Maintenance and Material Management System Staff, October 21, 1966.

Chief of Naval Material. Personal interview with W. P. Emery, Head of the Management Plans, Programs and Budget Branch, 3M Staff on March 9, 1967.

BOOKS

Gregory, Robert H. "[illegible] of Management Control Systems," in Management Control Systems. Edited by [illegible]. New York: John Wiley & Sons, Inc., 1960.

Gregory, R. H., and Van Horn, R. L. Automatic Data Processing Systems. Belmont, Calif.: Wadsworth Publishing Company Inc., 1960.

Matz, Adolph, Curry, Othel J., and Frank, George W. Cost Accounting. 2nd ed. Cincinnati, Ohio: South-Western Publishing Co., 1957.

Massie, Joseph L. Essentials of Management. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1964.

[illegible], Lars O. "The Framework for Evaluation—A [illegible] of Management Performance," Current Issues and Emerging Concepts in Management, edited by Paul M. Dauten, Jr. Boston: Houghton Mifflin Co., 1962.

[illegible], Samuel T. "The Systems Study," Systems and Procedures edited by Victor Lazzaro. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1959.

Nickerson, Clarence B. Managerial Cost Accounting and Analysis. 2d ed. New York: McGraw-Hill Book Co., 1962.

ARTICLES AND PERIODICALS

"The Managers Battle a Computer," Business Week, Nov. 12, 1960.

INTERVIEWS

Chief of Naval Personnel. Personal interview with [illegible], Deputy [illegible], Technical Advisor to the [illegible] and Material Management System [illegible], 1963.

Chief of Naval Material. Personal interview with [illegible], Assistant Deputy [illegible], [illegible] and Material Management System [illegible], October 11, 1963.

Chief of Naval Material. Personal interview with [illegible], Head of the Management [illegible] and [illegible] Branch, [illegible], March 6, 1964.

Naval Supply Systems Command. Personal interview with Mr. Kurt Fleming, Supply Management Specialist, October 19, 1966 and other numerous occasions.

Naval Air Force U.S. Atlantic Fleet. Personal interview with LCdr W. H. Rush and Stanley Nahill, AKC, staff members of the 3M implementation team, March 9, 1967.

Other Sources

Assistant Secretary of Air Force Speech, June, 1964. "Life Cycle Costing in Equipment Procurement."

The George Washington University Logistics Research Project Staff and Logistics and Mathematical Statistics Branch, Office of Naval Research, "A Survey of Information Requirements for Navy Maintenance and Material Management." Serial T-170, April 15, 1964.

The George Washington University Logistics Research Project by Marvin Denicoff and Sheldon Haber, "A Study of Usage and Program Relationships for Aviation Repair Parts," Serial T-140/62, August 7, 1962.

Logistics Management Institute, Washington, D. C. "Life Cycle Costing in Equipment Procurement," April, 1965.

Collins Radio Company. "Life Cycle Costing," prepared for the Department of Defense, August, 1966.

Letter from LCdr P. A. Lemma (SC) USN, Head of the Systems Planning Branch, Naval Aviation Supply Office, Philadelphia, Pa. January 9, 1967.

Letter from Captain E. J. Maiman, (SC) USN, Supply Officer U.S. Naval Air Station, Quonset Point, R. I. December 29, 1966.

Letter from Cdr J. P. Morgan, Jr., (SC) USN, Supply Officer U.S. Naval Air Station, Oceana, Va. December 16, 1966.

Letter from Cdr C. T. Seldon, (SC) USN, Supply Officer U.S. Naval Air Station, Brunswick, Maine. December, 1966.

Letter from Cdr E. E. Peterman, USN, Supply Officer, Naval Air Station, Key West, Florida, December 2, 1966.

Letter from Captain R. L. Watson, (SC) USN, Supply Officer, U.S. Naval Air Station, Jacksonville, Florida, November 30, 1966.

Letter from K. S. Hankland, Manager of Accounting, United Air Lines, San Francisco, Calif. February 15, 1967.

Naval Supply Systems Command. Personal interviews with the Fleet [illegible] Supply Management [illegible], October 19, 1966 and other [illegible].

Naval Air Systems Command, [illegible]. Personal interviews with [illegible] [illegible] [illegible], [illegible] [illegible] [illegible].

Other Sources

Additional proceedings of the [illegible] Company, [illegible], 1966. "Life Cycle Costing in Equipment Procurement,"

The George Washington University Logistics Research Project. [illegible] and Logistics and Mathematical Statistics Branch, Office of Naval Research, "A Survey of [illegible] Requirements for Navy Maintenance and [illegible] [illegible]," Serial T-179, April 11, 1966.

The George Washington University Logistics Research Project by Carvin Dahlhoff and Sheldon Haber, [illegible] Status and Progress, [illegible] for [illegible] [illegible]," Serial [illegible], August 7, [illegible].

Logistics Management Institute, Washington, D. C. "Life Cycle Costing in Equipment Procurement," April, 1965.

Dollins [illegible]. "Life Cycle Costing," [illegible] the Department of Defense, January, 1966.

Letter from LCDR [illegible] to [illegible], [illegible] [illegible] Fleeting [illegible], Naval [illegible] Supply [illegible], Mechanicsburg, Pa., January 4, 1967.

Letter from [illegible] [illegible], [illegible], [illegible] Supply [illegible] [illegible], [illegible] [illegible], [illegible] [illegible], December 6, 1966.

Letter from [illegible] [illegible], [illegible] [illegible], [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] 1966.

Letter from [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] 1966.

Letter from [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] 1966.

Letter from [illegible] [illegible], [illegible] [illegible] [illegible], [illegible] [illegible], [illegible], December 1, 1966.

Letter from [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] San Francisco, [illegible], September 19, 1966.